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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention reduces power consumption in more detail about the display which has a display device and an active device on a substrate, and it relates to the display which has a display device and an active device on the substrate which raised the homogeneity of luminescence intensity.

[0002]

[Description of the Prior Art]The typical display conventionally used for the purposes, such as an information display, is a cathode. Lei They are a tube (henceforth "CRT"), a liquid crystal display, and an EL display. CRT had high display quality, moreover, since apparatus cost was comparatively low, it had been widely used as a display until it continued till today, but there was a fault that the miniaturization of the cathode-ray tube used for this was difficult, and difficult also for reducing the electric power consumed by it. From such backgrounds, the demand of liquid crystal displays and EL displays is increasing quickly. Since especially the organic electroluminescence display device used in an EL display is a self-luminescence type, it can be driven by the low voltage, and moreover, since the display is clear, the expectation for an organic electroluminescence display device is growing.

[0003]These days, development of an electrophoresis display device has come to be performed actively. At least one side opens and carries out the placed opposite of the two substrates which consist of transparent substrates for a business interval via a spacer, and such an electrophoretic display forms a closed space, It is filled up with the display liquid which made this closed space distribute a particulate material (pigment component particles) in the carrier fluid colored the color from which this and a color tone differ, and is considered as a display panel, an electric field is impressed to this display panel, and an indication is given profitably like.In this electrophoretic display, the field of a transparent substrate turns into a display surface. A desired display can be obtained when this electrophoretic display controls direction of ** electric field, ** display liquid -- comparatively -- acquisition -- since it has the strong points, such as that it is an easy low cost material, that ** angle of visibility is large as much as [usual] printed matter, that ** power consumption is small, and having ** memory nature, it is observed as a display.

[0004]In addition, the field emission display (henceforth "FED") has also attracted attention in recent years. FED is displayed using the principle of luminescence by accelerating the electron emitted from the electron source in the vacuum by the electric field of space, and colliding with a fluorescent

substance.

[0005]On the other hand, as a general active device used for a display device, there is a thin film electric field effect type transistor with a gate electrode, a source electrode, and a drain electrode.

[0006]Drawing 6 is such a conventional thin film electric field effect type transistor. As shown in drawing 6, in the conventional thin film electric field effect type transistor, it is separated by the organic semiconductor layer (channel layer field) 102 which is neutral electrically, and the source electrode 101 and the drain electrode 103 are put in order and formed on the same flat surface. The gate electrode 104 is electrically separated by the gate insulating layer 109 from the organic semiconductor layer 102. A low voltage drive becomes possible, so that channel length is so short that channel width is so wide that the mobility of a semiconductor is large according to this thin film electric field effect type transistor (active device). However, since the area of an active device will increase if the channel width of an active device is increased, high integration of an element becomes difficult. Therefore, when this active device was used for the display, there was a problem that it became difficult to produce a high definition display.

[0007]In order to solve such problems, laminate a source electrode, a gate electrode, and a drain electrode one by one, and A field effect transistor. (It is hereafter called "SIT".) The compound-die organic electroluminescence transistors (active device) used as the active device of structure are a Japan Society of Applied Physics organicity molecule and a bioelectronics subcommittee. It was announced at the 9th school (2001).

[0008]Drawing 7 is the conventional compound-die organic electroluminescence transistor. In [as shown in drawing 7] the conventional compound-die organic electroluminescence transistor, The source electrode 201, the semiconductor layer 202, and the drain electrode 203 are laminated one by one, an interval is opened in the approximately center portion in this semiconductor layer 202, and this source electrode 201 and the drain electrode 203, and two or more cylindrical gate electrodes 204 arranged at abbreviated parallel are laminated. According to this compound-die organic electroluminescence transistor, it becomes possible to decrease the area of an active device, and it becomes possible to produce a high definition display.

[0009]

[Problem(s) to be Solved by the Invention]However, said compound-die organic electroluminescence transistor (active device), When not impressing voltage to the gate electrode 204, current flows between the source electrode 201 and the drain electrode 203, and when impressing voltage to the gate electrode 204, current is intercepted between the source electrode 201 and the drain electrode 203 (normally-ON). The channel length between the source electrode 201 and the drain electrode 203, Since the thickness of a semiconductor layer becomes thick, as compared with the usual transistor channel length by which it is shown to said drawing 6, it becomes short, therefore the electrical resistance between the source electrode 201 and the drain electrode 203 becomes small, and, as a result, the current at the time of OFF becomes large.

[0010]Drawing 8 is a circuit description figure of the gradation signal line in the conventional display, and a scanning line. In the display using the conventional active device, a gradation signal line is allotted between a source electrode and a drain electrode, and the scanning line is allotted to the gate electrode as shown in drawing 8. in such a display, as an active device, if said thin film electric field effect type transistor (drawing 6) is used, when impressing voltage to a gate electrode, the current will be

intercepted (normally-ON) -- by that. The electrical resistance between a source electrode and a drain electrode becomes high, and to eye others. Although a problem did not arise in the drive of the display, when said compound-die organic electroluminescence transistor (drawing 7) was used, since the time when the gradation signal line is an ON state as compared with the scanning line was overwhelmingly long, there was a problem that the power consumption of a display became large.

[0011]In said compound-die organic electroluminescence transistor, source/drain current (henceforth "S/D current") does not show saturation characteristics to source/drain voltage (henceforth "S/D voltage"). Drawing 9 is a graph showing the S/D voltage of such a conventional compound-die organic electroluminescence transistor, and the relation of S/D current. As shown in drawing 9 a compound-die organic electroluminescence transistor, Since the S/D current value was changed by change of slight S/D voltage, when this was used for the EL display in which it is specified to luminescence intensity with a current value, there was a problem that it was difficult to carry out controllability good, therefore the homogeneity of luminescence intensity was spoiled in a display surface with a current value in luminescence intensity.

[0012]An object of this invention is to solve this problem. That is, an object of this invention is to reduce power consumption and to provide the display which raised the homogeneity of luminescence intensity.

[0013]
[Means for Solving the Problem]An invention indicated to claim 1 is a display which has a display device and an active device on a substrate to achieve the above objects, This active device comprises a layered product which laminated a source electrode, a semiconductor layer, and a drain electrode one by one, this semiconductor layer opening an interval in the approximately center portion, and having this source electrode and a drain electrode, two or more cylindrical gate electrodes arranged at abbreviated parallel, or a gate electrode of one doughnut shape, and, In a display in which current which flows between this source electrode and a drain electrode in this active device flows into an abbreviated perpendicular direction to a substrate face, this display device is a display performing a gradation display with gate voltage impressed to a gate electrode of this active device.

[0014]In an invention an invention indicated to claim 2 was indicated to be to claim 1, A relation of a gate electrode installed number and channel width which were seen from a section of said active device is installed number $> 0.2 \text{ micrometer}$ (1) of the following formula {channel width (micrometer) - (installed number of a gate-electrode-width (micrometer) x gate electrode seen from a channel width direction)} / gate electrode.

***** -- it is characterized by things.

[0015]Gate dielectric film is formed in said gate electrode in an invention an invention indicated to claim 3 was indicated to be to claim 1 or 2.

[0016]In an invention indicated to either of claims 1-3, said gate electrode comprises metal and an invention indicated to claim 4 consists of a metallic oxide film formed by oxidation of the surface of a gate electrode in which said gate dielectric film comprises this metal.

[0017]In an invention indicated to either of claims 1-4, an invention indicated to claim 5 is characterized by said display device being an organic electroluminescence display device, a liquid crystal display element, an electrophoresis display device, or FED.

[0018]

[Embodiment of the Invention]Drawing 1 is a circuit description figure of the gradation signal line in the display in which the 1 embodiment of this invention is shown, and a scanning line. Drawing 2 is a

sectional view of the display in which the 1 embodiment of this invention is shown. Drawing 3 is an explanatory view explaining the process which came to complete this invention. Drawing 4 is an explanatory view of the gate electrode used for the activity in the display in which other 1 embodiments of this invention are shown. Drawing 5 shows the saturation region where S/D current is saturated to S/D voltage.

[0019]The display of this invention is the display 10 which has a display device (light emitting device) and an active device on the substrate 6, as shown in drawing 1, and 2 and 4, This active device comprises a layered product which laminated the source electrode 1, the semiconductor layer 2, and the drain electrode 3 one by one, this semiconductor layer opening an interval in the approximately center portion, and having this source electrode 1 and the drain electrode 3, two or more cylindrical gate electrodes 4 arranged at abbreviated parallel, or the gate electrode 24 of one doughnut shape, and, In the display 10 in which the current which flows between this source electrode 1 and the drain electrode 3 in this active device flows into an abbreviated perpendicular direction to the surface of the substrate 6, this display device performs a gradation display with the gate voltage impressed to the gate electrode 4 of this active device. Although said light emitting device has the substrate 6, the transparent electrode 7, the organic electroluminescence material layer 8, and the negative pole 1 that functions also as the source electrode 1 of an active device one by one, it is known well in the field. In the display shown in drawing 1, although it is a liquid crystal cell (liquid crystal display element), as it is shown in drawing 2, it may be a light emitting device and is not illustrating, but even if a display device is an electrophoresis display device or FED, it is not cared about.

[0020]an active device with SIT structure in the display of this invention -- namely, -- "it comprising a layered product which laminated the source electrode 1, the semiconductor layer 2, and the drain electrode 3 one by one, and, This semiconductor layer is what performs a gradation display with the gate voltage impressed to the gate electrode 4 of" active device which opens an interval in the approximately center portion, and has this source electrode 1 and the drain electrode 3, two or more cylindrical gate electrodes 4 arranged at abbreviated parallel, or the gate electrode 14 of one doughnut shape. Since it is, it becomes possible to make small power consumption of the display using an active device with SIT structure. The reason is as follows. Namely, as shown in drawing 1, the electrical resistance between a source electrode (S) and a drain electrode (D) is low, but. Since ON/OFF between a source electrode (S) and a drain electrode (D) is dependent on the ON/OFF signal impressed to a gate electrode (G) through a hierarchy signal wire from a driver circuit, current does not flow through it between a source electrode (S) and a drain electrode (D) at the time of OFF. It is because the electric charge of a phase-voltages this taken out from the gradation signal line is once accumulated in a capacitor when an ON signal is taken out, so this electric charge is held till the end of a full line scanning, therefore a liquid crystal cell (liquid crystal display element) is driven by this electric charge.

[0021]In order to attain the purpose of said this invention, when this invention person considered the active device of the conventional SIT structure based on the experiment, he found the following thing. The gate electrode in the active device of SIT conventional structure comprises two or more Kushigata electrodes as shown in drawing 3 (a). In drawing 3 (a), 1 is a source electrode, 2 is a semiconductor (n type), 3 is a drain electrode, and 4 is a gate electrode, and 5 is semiconductor membrane (p type). In this conventional active device, when inter electrode distance is formed very with high definition, even if the small S/D voltage of less than gate voltage is impressed, a depletion layer spreads in the whole channel

width simultaneously with gate voltage impression. If S/D voltage is impressed in such a state, an electron is poured into this depletion layer and this electron moves in the direction of a drain in accordance with the electric field. In order that the flow of the current by pouring of the electron to this depletion layer may not change S/D voltage from a low field to a high field to gate voltage, S/D current is not saturated to S/D voltage. Control of S/D current is mainly performed, when the thickness of a depletion layer increases by the increase in gate voltage, but since the resistance between a source electrode and a drain electrode will increase if the thickness of a depletion layer increases in this way, the value of S/D current decreases also in the same S/D voltage.

[0022]If the semiconductor layer (n type) 2 is formed in a channel part, the semiconductor membrane (p type) 5 is formed near the gate electrode and negative potential is impressed to the active device as gate voltage as shown in drawing 3 (b), a depletion layer will be formed around a gate electrode. Under the present circumstances, there are a field where the depletion layer exists, and a field where a depletion layer does not exist in the channel part in this active device. If S/D voltage is impressed to an active device in this state, current flows through the part where resistance is low, i.e., the field where the depletion layer of a channel part does not exist. When it is in such a state, S/D current also increases with impression of S/D voltage. Since it will become so high that reverse bias when it sees from pn junction approaches the anode impression electrode of S/D voltage if S/D voltage is raised, a depletion layer on either side is connected near the anode as shown in drawing 3 (c). Even if it makes S/D voltage increase in this state, the electrical property with which S/D current as the voltage of increment impressed to a depletion layer, and the impressed electromotive force of channel both ends not changed a lot, for this reason shown in the graph of drawing 5 is saturated is acquired.

[0023]Therefore, in a depletion layer, it becomes important to detach and install the distance between gate electrodes in a proper distance so that may not be formed throughout channel width at the time of gate voltage impression as shown in drawing 3 (a).

[0024]Then, the place for which this invention person continued the experiment further based on said consideration, and it searched, The relation of the gate electrode installed number and channel width which were seen from the section of an active device is installed number $>0.2\text{micrometer (1)}$ of the following formula, and {channel width (micrometer) - (installed number of the gate-electrode-width (micrometer) x gate electrode seen from the channel width direction)} / gate electrode.

If it is ***** (ing), and it will become possible to acquire an electrical property which goes into the saturation region where S/D current is saturated to S/D voltage and this electrical property will be used as shown in drawing 5. It finds out that the active device which controls luminescence intensity and can improve the homogeneity of luminescence intensity is obtained, and came to complete this invention.

[0025]That is, the relation of the gate electrode installed number and channel width which saw the active device in this invention from the section of the active device is installed number $>0.2\text{micrometer (1)}$ of the following formula {channel width (micrometer) - (installed number of the gate-electrode-width (micrometer) x gate electrode seen from the channel width direction)} / gate electrode.

It is ***** (ing). Preferably, although those sections are rectangles, said cylindrical gate electrode 4 may have the other sectional shape, unless it is contrary to the purpose of this invention.

[0026]According to this invention, the relation of the gate electrode installed number and channel width which were seen from the section of an active device, If installed number $>0.2\text{micrometer}$ of the formula (1), i.e., {channel width (micrometer) - (installed number of the gate-electrode-width (micrometer) x

gate electrode seen from the channel width direction)) / gate electrode, is filled, as shown in drawing 5. The display device which has the active device and it which it becomes possible to acquire an electrical property which goes into the saturation region where S/D current is saturated to S/D voltage, therefore control luminescence intensity, and can improve the homogeneity of luminescence intensity can be provided.

[0027]And in said formula (1), "the gate electrode width seen from the channel width direction" is the width of a gate electrode when all the gate electrode width is constant in a rectangular cross section, as drawing 1 is shown. The molecule of the formula (1) shows total of the length of the part in which the gate electrode is not formed among channel width. By dividing this length by a gate electrode installed number, the average length of the distance between gate electrodes is obtained. When the width of a gate electrode is not constant, it is necessary to compute the quantity equivalent to the molecule of a formula (1) separately. When only one thing from which gate electrode shape when seen from the active device upper surface turned into the shape of an anchor ring like drawing 4 for example, instead of Kushigata is formed, Since two gate electrodes appear in an element section, in such a case, in this invention, a gate electrode installed number is defined as 2. In this invention, it is shown that the average length of the distance between this gate electrode exceeds 0.2 micrometer, and it becomes possible to acquire an electrical property as is shown to drawing 5 by this. So, according to this invention, the display device which has the active device and it which control luminescence intensity and can improve the homogeneity of luminescence intensity can be provided.

[0028]The material which constitutes the semiconductor layer 2 in this invention, Preferably ** naphthalene, anthracene, tetracene, pentacene, The acene molecule material chosen from the group which consists of HEKISASEN and those derivatives, ** The paints chosen from the group which consists of a phthalocyanine system compound, an azo compound, and a perylene system compound, and its derivative, ** A hydrazone compound, a triphenylmethane compound, a diphenylmethane compound, a stilbene compound, an aryl vinyl compound, a pyrazoline compound, a triphenylamine compound, and doria -- the low molecular weight compound chosen from the group which consists of a reel amine compound, and its derivative. Or ** *****- alkyl thiophene, poly-N-vinylcarbazole, It is a high molecular compound chosen from the group which consists of halogenation poly-N-vinylcarbazole, polyvinyl pyrene, polyvinyl anthracene, pyrene formaldehyde resins, and ethylcarbazole formaldehyde resins. It is usable also in a fluorenone system, a diphenoquinone system, a benzoquinone series, an anthraquinone system, and a yne DENON system compound. The material which constitutes the semiconductor membrane 5 in this invention is organic materials chosen from the aforementioned **-* preferably.

[0029]Thus, it becomes possible to adopt methods [be / the material which constitutes said semiconductor / organic materials], such as vacuum evaporation and spreading, in membrane formation of the semiconductor layer 2 and the semiconductor membrane 5, therefore becomes effective in reduction of manufacturing installation cost, and reduction of element cost.

[0030]The gate electrode 4 in this invention, the source electrode 1, and the drain electrode 3, Preferably Chromium (Cr), Ta (thallium), titanium (Ti), Copper (Cu), aluminum (aluminum), molybdenum (Mo), tungsten (W), It comprises at least one sort of materials chosen from the group which consists of nickel (nickel), gold (Au), palladium (Pd), platinum (Pt), silver (Ag), tin (Sn), conductive polyaniline, conductive polypyrrole, conductive polythiazyl, and a conductive polymer.

[0031]The gate electrical insulation film is preferably formed in the gate electrode 4 in this invention.

Such a gate electrical insulation film preferably, A silica dioxide, silicon nitride, barium titanate strontium, barium titanate zirconate, Lead zirconate titanate, a lead titanate lantern, strontium titanate, Barium titanate, barium fluoride magnesium, titanate bismuth, It comprises at least one sort of materials chosen from the group which consists of strontium titanate bismuth, tantalum pentoxide, and strontium bismuth tantalate, niobium tantalate acid bismuth, a titanium dioxide, and 3 yttrium oxide. Said gate electrical insulation film is a metallic oxide film formed by oxidation of the surface of the gate electrode which comprises metal still more preferably. Such a metallic oxide film is an oxide film of Ta preferably.

[0032] Thus, since the Schottky barrier will be formed between this gate electrode and semiconductor layer 2 if the gate electrical insulation film is formed in the gate electrode 4, it becomes possible to become possible to prevent the current leakage from a gate, therefore to impress voltage high as gate voltage. So, it becomes possible to make the current at the time of OFF small as much as possible by impression of gate voltage as shown in drawing 3 (b) in the element which intercepts S/D current, and it becomes possible to press down the power consumption of an element. A gate electrical insulation film becomes possible [obtaining a reliable insulator layer easily as it is the metallic oxide film formed by oxidation of the surface of the gate electrode which comprises metal]. If such a metallic oxide film is formed by oxidation of Ta, much more reliable electric insulation will be attained.

[0033] The substrate in the display device of this invention comprises material chosen from the high dope silicon in which the insulator layer was formed on glass, a plastic, quartz, and the surface, for example.

[0034] The EL material which constitutes the EL material layer in the display device of this invention, ** At least one sort of fluorescent brighteners chosen from a benzothiazole system fluorescent brightener, a benzimidazole system fluorescent brightener, and the fluorescent brightener of a benzooxazol system, ** A metal chelate-ized oxy NOIDO compound, a styryl benzenoid compound, Non [JISUCHIRIRU pyrazine derivative polyphenyl system compound, and 12-phthaloperi], 1,4-diphenyl-1,3-butadiene, 1,1,4,4-tetraphenyl-1,3-butadiene, A NAFUTARU imide derivative, a perylene derivative, an oxadiazole derivative, An aldazine derivative, a PIRAJIRIN derivative, a cyclopentadiene derivative, at least one sort of metal complexes chosen from a pyrrolo pyrrole derivative, a styryl amine derivative, a coumarin series compound, an aromatic dimethyldiyne compound, and an eight-quinolinol derivative -- or, ** They are at least one sort of polymer materials chosen from polyphenylene vinylene, its derivative, Polyful Oren, and its derivative.

[0035]

[Example](Example 1) it having a drain electrode which consists of Au(s), a semiconductor layer which consists of CuPc(s), and a source electrode which consists of LiF(s) one by one, and, The active device which has a gate electrode which consists of cylindrical aluminum of two or more rectangular cross sections which opened the interval in the approximately center portion in said semiconductor layer, and have been arranged at said drain electrode and said source electrode, and abbreviated parallel (refer to drawing 7), Display an image pattern one by one with gradation 0%, 50%, and 100%, using the liquid crystal cell of a TN mode (transmission type; back light use), and the drive circuit shown in drawing 1 (cycle of 1 Hz), and. Pixel number: When the liquid crystal display was driven and power consumption was measured as 200x200 and liquid crystal driving voltage:5V, power consumption was 0.1W as a value of the maximum electric power consumption of only an actuator. When this power consumption showed the power consumption in the comparative example 1 shown below with the relative value when

referred to as 1.00, it was 0.62.

[0036](Comparative example 1) When the liquid crystal display was driven like Example 1 except having used what shows drawing 8 a drive circuit and power consumption was measured, power consumption was 0.159W as a value of the maximum electric power consumption of only an actuator.

[0037](Example 2) A glass substrate, the transparent substrate which consists of ITO(s), the electrode which consists of LiF(s) (negative pole), it having an organic electroluminescence material layer which consists of PPV system material, a semiconductor layer which consists of material which replaced end hydrogen of the copper phthalocyanine by fluoride (n type), and a drain electrode which consists of Au (s) one by one, and, The gate electrode which consists of cylindrical aluminum of two or more rectangular cross sections which opened the interval in the approximately center portion in the aforementioned (n type) semiconductor layer, and have been arranged at said electrode (negative pole) and said drain electrode, and abbreviated parallel is laminated, When the light emitting device in which the semiconductor membrane which comprises a p-type semiconductor which consists of a Polly 3-hexylthiophene all over said gate electrode was formed was 1 pixel, the display device (drawing 2) which has this 200x200 pixels was manufactured. At that time, channel width was 50 micrometers, the gate electrode width seen from the channel width direction was 1 micrometer, the number of gate electrodes was changed into 7-40 pieces, and seven sets of display devices were manufactured.

[0038]The gate voltage preset value was set as 0.5V for the display device of Example 2 manufactured in this way, and the S/D voltage set value was set as 3.5V, and viewing estimated the homogeneity of the luminescence intensity of the display surface. The valuation basis is O..... Light is emitted uniformly satisfactorily practical.

x There is emission unevenness a little.

It carried out. An evaluation result is shown in the next table 1.

[Table 1]

| 式 (1) における値 | | | | | | |
|---------------|-------|-------|-------|-------|---------|---------|
| 6 . 8 | 4 . 5 | 3 . 2 | 1 . 1 | 0 . 5 | 0 . 2 5 | 0 . 1 8 |
| ○ | ○ | ○ | ○ | ○ | ○ | × |

[0039]

[Effect of the Invention](1) according to the invention indicated to claims 1 and 5, it comprising a layered product which laminated the active device with SIT structure, i.e., "source electrode, the semiconductor layer, and the drain electrode one by one, and, Since the gate voltage impressed to the gate electrode of" active device which has two or more cylindrical gate electrodes in which this semiconductor layer opened the interval in the approximately center portion, and has been arranged at this source electrode and a drain electrode, and abbreviated parallel, or a gate electrode of one doughnut shape performs a gradation display, It becomes possible to make small power consumption of the display using an active device with SIT structure.

[0040](2) According to the invention indicated to claim 2, the relation of the gate electrode installed number and channel width which were seen from the section of an active device, Since installed number $> 0.2 \text{ micrometer}$ of the formula (1), i.e., $\{\text{channel width (micrometer)} - (\text{installed number of the gate-electrode-width (micrometer)} \times \text{gate electrode seen from the channel width direction})\} / \text{gate electrode}$, is filled, The display device which has the active device and it which it becomes possible to acquire an electrical property which goes into the saturation region where S/D current is saturated to S/D voltage as shown in drawing 5, therefore control luminescence intensity, and can improve the homogeneity of luminescence intensity can be provided.

[0041](3) Since the gate electrical insulation film is formed in the gate electrode according to the invention indicated to claims 3 and 4, Since it becomes possible to form the Schottky barrier between this gate electrode and semiconductor layer, therefore to prevent the current leakage from a gate and becomes possible to impress voltage high as gate voltage therefore, it becomes possible to obtain a high ON/OFF ratio. A gate electrical insulation film becomes possible [obtaining a reliable insulator layer easily as it is the metallic oxide film formed by oxidation of the surface of the gate electrode which comprises metal].

[Translation done.]